

Arachnida (Arthropoda: Chelicerata) of Western Australia: overview and prospects

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The history of the study of arachnids (spiders, scorpions, ticks, mites and their relatives) in Western Australia is briefly reviewed, and the main periods of activity are documented: 1860s–1910s, between the wars, after World War II, and the modern era. The fauna consists of at least 1400 named species (but the mite fauna is imperfectly documented), and it is estimated that ~6000 species exist, the majority of which are currently undescribed

KEYWORDS: history, pseudoscorpions, scorpions, spiders, taxonomy.

INTRODUCTION

The arachnid fauna of Western Australia represents a fascinating tableau of ancient relictual species and more recently arrived invaders. While the spiders (order Araneae) and mites (superorder Acari) are numerically dominant, representatives of six other orders—Scorpiones, Pseudoscorpiones, Opiliones, Schizomida, Amblypygi and Palpigradi (Figure 1)—have been found in the state. The size of the fauna is unknown, but certainly comprises several thousand species, the majority of which are undescribed and lack valid scientific names.

The history of discovery of the arachnid fauna of the region can be conveniently divided into four time periods: 1860s–1910s, between the wars, after WWII, and the Modern Era, and I here present a brief overview of the major researchers and their areas of expertise.

1860s–1910s

The first arachnids to be described from specimens explicitly collected in Western Australia were various trap-door spiders collected in 'Swan River' or 'West Australia' and studied by Oliver Pickard-Cambridge (1828–1917: usually cited as O P-Cambridge by the arachnological community), an English clergyman and zoologist based in Bloxworth, England. The first species to be named were the trap-door spiders *Eriodon granulosum* and *E. crassum* by Cambridge (1869). Both specimens were taken from 'Swan River' which at the time referred to the Swan River Colony. *Eriodon granulosum* was based on a single male, and *E. crassum* was based on a female, and it took nearly 80 years before they were recognised as the same species which is

nowadays known as *Missulena granulosum* (Cambridge). This species is quite common throughout southwestern Australia where it persists in woodland habitats. The next arachnid to be described was *Idiops blackwalli* Cambridge (1870) based on an adult male collected from Swan River. The species was quickly transferred to a new genus by Ausserer (1871). *Idiommata blackwalli* is a large, impressive species still common in the Perth region. The trapdoor spiders *Aganippe latior* (based on a female from 'West Australia'), *Eriodon insignis* (based on a male from Swan River), and *E. incertus* (a male from Swan River) were also described by Cambridge, but in 1877 (Cambridge 1877). Unfortunately, there is little background information regarding how the specimens came to be sent to England as the name of the collector of the specimens was not mentioned by Cambridge in his papers.

During the exploration by the British settlers, natural history specimens started to trickle back to England, where many different arachnids were studied by local scientists keen to document the fauna of the world. Specimens were also being sent to the Australian Museum in Sydney where spider expert William J Rainbow (1856–1919) was documenting many new species of different families. Some notable additions to the Western Australian arachnid fauna of the time included studies on scorpions (Pocock 1891, 1898, 1902) and spiders (Hogg 1914; Rainbow 1914; Rainbow & Pulleine 1918).

Around the turn of the 20th century European museums were funding scientists to visit various parts of the world to amass scientific collections to better understand the world's biota. The Michaelsen–Hartmeyer expedition to southwestern Australia was typical of the time, with two distinguished German scientists traveling to far-flung corners of the globe to document the biota of a region and to bring specimens back for their institutional scientists and colleagues to study. Wilhelm Michaelsen (1860–1937) and Robert Hartmeyer (1874–1923) stayed in Western Australia for several months in 1905 and travelled as far north as Shark Bay, south to Albany and east to Kalgoorlie and Norseman (Michaelsen & Hartmeyer 1907–1908), collecting in both terrestrial and marine habitats. The then Director of the Museum, Bernard H Woodward

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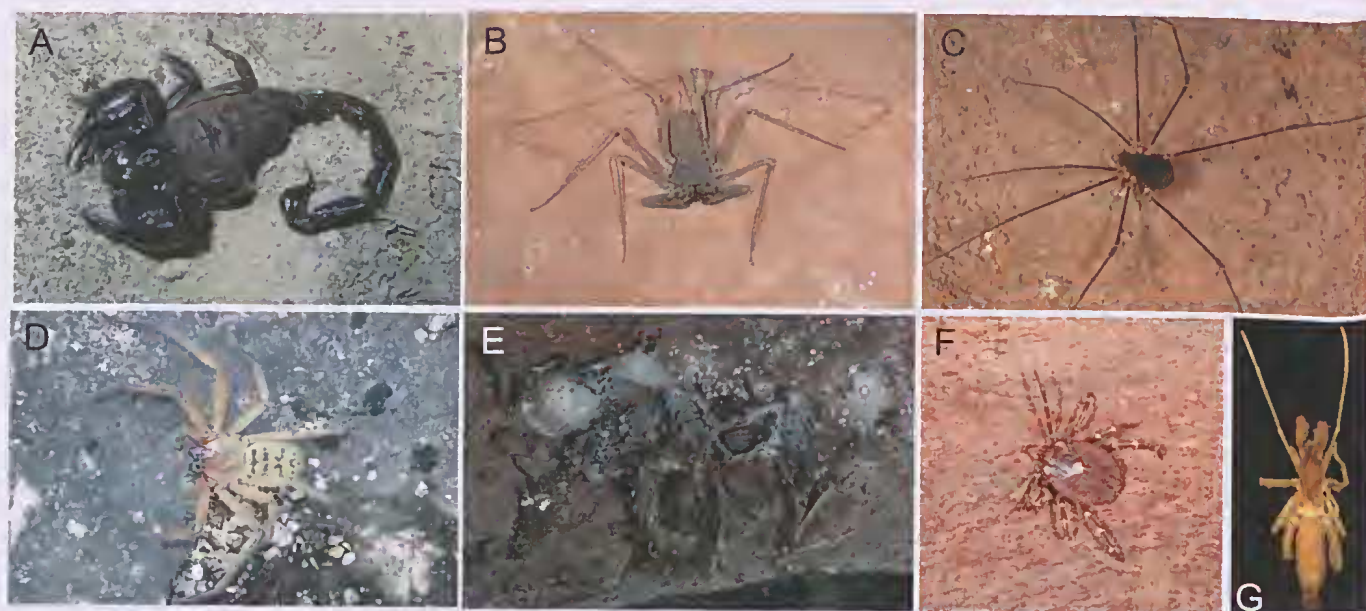


Figure 1 Representative orders of Western Australian Arachnida. (a) Scorpiones, *Urodacus bulleri* Volschenk, Harvey and Prendini. (b) Amblypygi, *Charon* sp.. (c) Opiliones, *Dampetrus* sp.. (d) Araneae, *Delena lapidicola* (Hirst). (e) *Synsphyronus apimelus* Harvey. (f) Acarina, *Amblyomma triguttatum* L. Koch. (g) Schizomida, *Paradraculoides bythius* Harvey, Berry, Edward & Humphreys. Images by Western Australian Museum.

lamented that the Western Australian government had supplied funds and equipment to assist the German expedition, but provided little in the way of assistance to the fledging Museum. Michaelsen and Hartmeyer dispatched specimens collected during their journey to a variety of European colleagues, all specialists in their discipline. Several arachnid groups were treated by taxonomists, and the most important contribution was the section on spiders published in two parts by the eminent French spider expert Eugène Simon who was based at the Muséum national d'Histoire naturelle, Paris (Simon 1908, 1909). In these papers he described 160 new species and 21 new genera. The specimens were divided between the museums of Berlin, Hamburg and Paris, with a few specimens sent to the Western Australian Museum (Main & Harvey 1992). Despite their value as type specimens, the Western Australian Museum specimens were removed from ethanol and mounted on pins; they were then displayed in the public gallery of the museum for many years. They have since been returned to ethanol and stored amongst the research collections of the museum (Main & Harvey 1992). Three other arachnid groups collected during the Michaelsen–Hartmeyer expedition were studied by taxonomists. The scorpions were examined by Karl Kraepelin who recorded several different species, including several new species (Kraepelin 1908). Albert Tullgren, a Swedish scientist who specialised in the study of arachnids, examined the few pseudoscorpions collected by the German pair (Tullgren 1909). He described three new species. Lohmann (1909) worked on the marine mites, of which very few were collected.

The Swedish zoologist and ethnographer Eric Georg Mjöberg (1882–1938) also visited Western Australia, making pioneering collections in the Kimberley. The only arachnids that were documented from that collection were the scorpions (Kraepelin 1916).

BETWEEN THE WARS

Ludwig Glauert

Ludwig Glauert (1879–1963) (Figure 2a) was born in Yorkshire, England and trained as a geologist before emigrating to Perth in 1908. He was appointed to the Western Australian Museum in 1910 after a short stint with the Geological Survey of Western Australia. He led the museum as Keeper of the Biological Collections after his return from service in World War I in 1920. This title was altered to Curator in 1927 and to Director in 1954.

Although responsible for building the collections of the fledging Western Australian Museum, Glauert was also responsible for the very first arachnids to be described from Western Australia by a person resident in the state. He described several species of marbled scorpions of the family Buthidae from Australia (Glauert 1925), including *Lychas jonesae* from the Goldfields region of Western Australia. In this seminal paper, he also described several species from other parts of Australia. The type specimen of *L. jonesae* was based on a specimen lodged in the collection of the Western Australian Museum, where it resides to this day. Although his 1925 paper was tantalizingly titled 'Australian Scorpionidea. Part 1', subsequent parts in this series were never published even though he was working on scorpion manuscripts up until his death in 1963 (Serventy 1963). These were published posthumously in 1963, one containing the description of a remarkable new species of *Urodacus* from the Canning Stock Route (Glauert 1963b), and the other consisting of a list of Western Australian scorpions (Glauert 1963a).

Glauert maintained correspondence with prominent arachnologists of the time and was responsible for dispatching harvestmen specimens on loan to two specialists, who published the results of their studies. The

German Carl-Friedrich Roewer (1881–1963) was a world-renowned and prolific specialist who published on the samples sent to him by Glauert (Roewer 1929), including the new genus and species, *Bindoona glauerti* Roewer, 1929. The genus was named in honour of the town of Bindoon, from where the specimens had been collected, and the species was named, of course, in honour of Glauert. Glauert also lent harvestmen specimens to the young and energetic New Zealand arachnologist Raymond Forster (1922–2000), who published the results of his study in 1952 (Forster 1952). The most important species was yet another new genus and species, *Dingupa glauerti*, this time named for the small hamlet of Dingup, but also for the collector.

Herbert Womersley (1889–1962) was born in Lancashire and moved to Australia with his wife and children in 1930 to take up a three-year post with the Division of Economic Entomology (C S & I R, later to become CSIRO) to study the distribution and control of two introduced pests, clover springtail [*Sminthurus viridis* (Linnaeus)] and the red-legged earth mite [*Halotydeus destructor* (Tucker)]. Due to the financial difficulties facing organisations such as C S & I R during the Great Depression, Womersley left Western Australia and joined the South Australian Museum in 1933. He worked there for the rest of his professional life until his retirement in 1959, first as Entomologist, and after 1954 as Acarologist.

While living in Perth, Womersley befriended a young entomologist Duncan Campbell Swan (1907–1960), who was born in Perth and who studied at the University of Western Australia, and received a Master of Science degree at the University of Adelaide in 1935. After serving in the Medical Unit of the Royal Australian Air Force during World War II, Swan became head of the Department of Entomology at the Waite Institute in Adelaide, South Australia (Prescott & Brookes 1961). Swan became a renowned medical and agricultural entomologist, but he holds the honour of being the first person born in Western Australia to describe a new Western Australian arachnid. Furthermore, this description was only the second arachnid to be named by a resident of Western Australia, after *Lychas jonesae*. Swan described a new species of tick, *Ixodes hydromyidis* (Swan 1931), which had been collected from a water rat (*Hydromys fuliginosus*) and a black rat (*Rattus rattus*) in the hills near Perth. Quite fittingly, the specimens from

Hydromys had been collected by Ludwig Glauert, demonstrating his considerable skills in promoting the study of the Western Australian fauna. Swan's holotype specimen is lodged in the Western Australian Museum.

There appears to be relatively little other arachnological activity during this time, apart from the description of some new Western Australian mites (Hirst 1928).

AFTER WORLD WAR II

Barbara York Main

Barbara York (Figure 2b) was born in 1929 and grew up on the family farm at Tammin, in the heart of Western Australia's wheatbelt. After correspondence classes organised through the Western Australian Education Department under the tutelage of her mother, a former teacher, she was awarded a scholarship to Northam High School. She entered the University of Western Australia in 1947 and graduated with an Honours degree in Science, majoring in Zoology in 1950. During classes at the university she met her future husband, Albert (Bert) Main (1919–2009), a returned serviceman who was imprisoned in Europe during World War II. Her PhD was awarded by the University in 1956 for a thesis studying aganippine trapdoor spiders, which formed the basis of a paper published the following year (Main 1957). Since then she has produced a steady stream of publications devoted to the biology, natural history and taxonomy of spiders, particularly mygalomorph spiders (e.g. Main 1985, 1993, 2001b; Main & Framenau 2009; Mason *et al.* 2013). Her first scientific paper (Main 1952) included the description of two new species of the trapdoor spider genus *Idiosoma*, representing only the second and third arachnid species to be named by someone born in Western Australia.

She has also contributed papers on the biogeography of the region (Main 1991, 1998, 1999, 2001a; Main *et al.* 2000), and strongly promoted the conservation of spiders and other 'forgotten' invertebrates. Her books on natural history, including *Between Wodjil and Tor* (Main 1967) and *Spiders* (Main 1976, 1984), have received national acclaim. Further details of Barbara's life and career are provided by Hodgkin (1995).

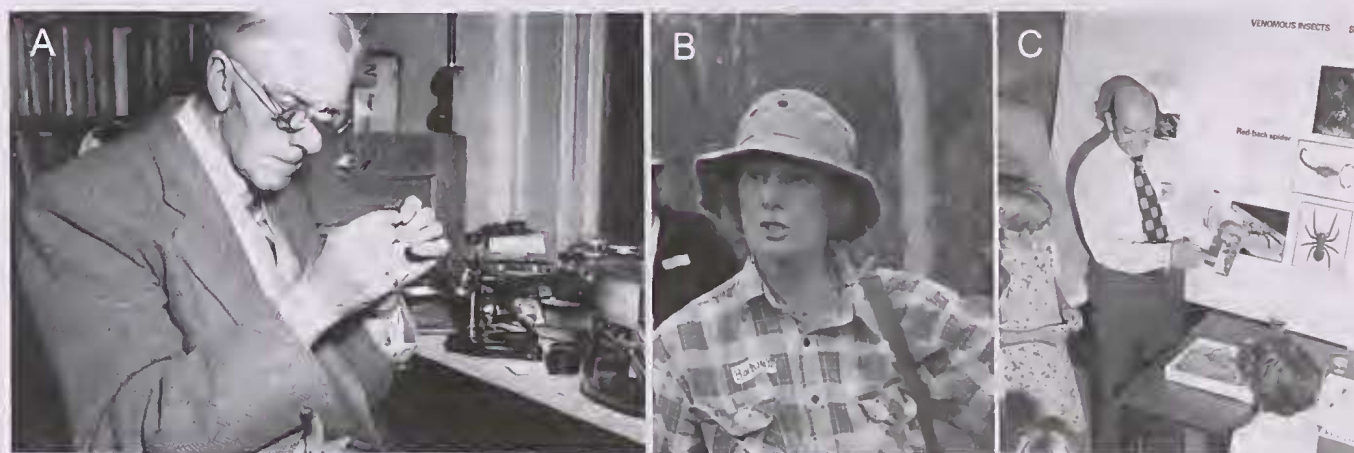


Figure 2 (a) Ludwig Glauert. (b) Barbara York Main. (c) Lucien E Koch. Images by Western Australian Museum.

Her first post-graduate student, Michael Gray, completed his Master of Science thesis in 1968 at the University of Western Australia entitled 'Comparison of three genera of trapdoor spiders (Ctenizidae, Aganippini) with respect to survival under arid conditions'. He went on to become Curator of Arachnids at the Australian Museum in Sydney, retiring in 2005.

The high regard in which Barbara Main is held amongst invertebrate systematists is that she has had more than 20 species named in her honour, including 13 spiders, as well as several genera including the spiders *Bymainiella* Raven (Raven 1978) and *Mainosa* Framenau (Framenau 2006), and the pseudoscorpion *Barbaraella* Harvey (Harvey 1995a).

Lucien Everard Koch

Lucien Koch (Figure 2c) was born in 1932 in Colombo, Sri Lanka (then Ceylon) where he completed his early education followed by tertiary education at the University of Western Australia. After a short stint from 1955 at the Department of Agriculture, he transferred to the Western Australian Museum where he was Curator of Entomology which at the time also encompassed the field of arachnology. His role altered to Curator of Arachnology with the appointment of an entomologist in 1980.

His arachnological research focused on the Australian scorpion fauna (Koch 1963, 1970, 1978, 1981), culminating in a systematic review of the scorpions of the entire region in which he described seven new species (Koch 1977). This body of work formed the basis for his PhD which he received from the University of Reading, United Kingdom, under the supervision of W D L Ride (1926–2011), who was at the time Director of the Western Australian Museum. Koch also published a review of the scolopendrid centipedes of Australia (Koch 1983a, b; Koch & Colless 1986), stabilising the identity of these iconic invertebrate predators. He retired from the Museum in 1987.

MODERN ERA

Graeme Talbot Smith (1938–1999) joined the CSIRO Division of Wildlife Research in Perth in 1974 where he spent nearly 20 years studying birds, mammals and scorpions. His ecological research on Western scorpions led to several important publications (Abensperg-Traun & Smith 1999; Smith 1990, 1998; Smith & McKenzie 2000) and he also contributed to the description of a new species of *Urodacus* from the Shark Bay region (Volschenk *et al.* 2000). He retired in 1993, and after his death six years later, his collection was transferred to the Western Australian Museum.

Western Australian spiders were also studied by an unlikely source, the Western Australian Museum's Assistant in the fish section, Roland (Roly) J McKay, who commenced employment in 1964. He began a revision of the Australian wolf spiders in 1968, initially using Barbara Main's large collection and notes (McKay 1973). By the time he published his first paper (McKay 1973), he had transferred to Brisbane as the Curator of Fishes at the Queensland Museum. He eventually published 15 papers over a 13 year span with his final contributions in 1985 (McKay 1985a, b).

During Lucien Koch's curatorship, Julianne Waldock was appointed as technical officer in the arachnology section of the Western Australian Museum in 1982, a post she still holds. She studied at the University of Western Australia, and has published descriptions of several new species (Waldock 1995, 2009; Žabka & Waldock 2012).

William (Bill) F Humphreys started employment at the Western Australian Museum in 1980 after studying in England, completing a PhD at the Australian National University, Canberra and a postdoctoral appointment at La Trobe University. Although originally employed as part of the Biogeography and Ecology section of the museum, he devoted part of his research program to the study of the surface structure of the eggs of chelicerates, particularly spiders (Humphreys 1983, 1987, 1995). He later turned his attention to the study of troglobitic animals, in particular the schizomid *Schizomus vinei* Harvey [later to become *Draculoides vinei* (Harvey)], partly based on data collected by Brian Vine in the relatively unexplored caves of the Cape Range region (Humphreys 1990; Humphreys *et al.* 1989; Vine *et al.* 1988). This work led to the discovery of high biological diversity in many different subterranean ecosystems throughout Western Australia, including the discovery and detailed documentation of many arachnids (Harvey & Humphreys 1995; Humphreys 1993, 2001).

After L E Koch's retirement, Mark Harvey was appointed Curator of Arachnids at the Western Australian Museum in 1989, after completing his PhD at Monash University in 1983 and postdoctoral appointments at the Division of Entomology, Canberra and the Museum of Victoria, Melbourne. He has mentored several postgraduate students and postdoctoral arachnological researchers at the Museum and via collaborative links with local universities, including Erich Volschenk (scorpions), Karen Edward (millipedes and spiders), Volker Framenau (spiders), Christopher Taylor (harvestmen), Danilo Harms (spiders and pseudoscorpions) and Michael Rix (spiders). He has published numerous papers on the arachnid fauna of Western Australia and elsewhere, and described many new arachnid species often in collaboration with his research team, belonging to several different orders including pseudoscorpions (Harvey 2012; Harvey & Edward 2007; Harvey & Leng 2008; Harvey & Volschenk 2007), spiders (Harvey 1995b, 2002), scorpions (Volschenk *et al.* 2012; Volschenk *et al.* 2000), schizomids (Harvey 1988, 2001; Harvey *et al.* 2008), water mites (Harvey 1996, 1998a, b) and palpigrades (Barranco & Harvey 2008).

Arachnids have also featured heavily in wide-scale biological surveys of significant sections of the state to gain a better idea of biotic assemblages and their conservation needs. These include surveys of the Kimberley rainforests (McKenzie *et al.* 1991), southern Carnarvon Basin (Burbidge *et al.* 2000), the Agricultural Zone and Wheatbelt (Keighery *et al.* 2004) and the Pilbara (George *et al.* 2009). These surveys have also been complemented by more localised studies of spider assemblages including the southwest forests (Brennan *et al.* 2004a, b) and the arid zone (Langlands *et al.* 2006, 2010).

Table 1 Numbers of named arachnid species collected in Western Australia, based on specimens lodged in the Western Australian Museum.

Order	Named species (indigenous)	Introduced species	Total	Comments
Acari	400	2	402	The taxon "Acari" is used in the broadest sense; see Krantz & Walter (2009) for alternative classification
Amblypygi	0	0	0	An undescribed species of whip spiders has been recently recorded from northern Western Australia (Harvey <i>et al.</i> 2012b)
Araneae	860	18	878	–
Opiliones	24	0	24	–
Palpigradi	1	1	2	–
Pseudoscorpiones	79	2	81	–
Schizomida	14	0	14	–
Scorpiones	29	0	29	–
Totals	1407	22	1429	–

THE FUTURE

The Western Australian arachnid fauna is moderately diverse, with more than 1400 named indigenous species represented in the collections of the Western Australian Museum (Table 1). This figure is an underestimate of the entire fauna as specimens of many species, especially mites, are not represented in the Western Australian Museum collections. However, this figure is relatively accurate for the other orders. There are also several notable introduced species, including the pests red-legged earth mite (*Halotydeus destructor*) and cattle tick (*Rhipicephalus microplus*); the spider families Agelenidae, Oecobiidae, Scytodidae and Sicariidae are only represented by introduced species.

The total extent of the arachnid fauna of Western Australia is difficult to estimate, as new species are continually being recognised and documented, but the lag-time until the species is formally named can be extensive. This masks the overall diversity of the group.

An estimate of ~6000 species would not be unreasonable, with ~3500 mite species, 2000 spiders and ~500 species of the smaller orders.

The majority of arachnological research in Western Australia over the past 150 years has been focused on taxonomy in an attempt to document the fauna of the state. The success of that progress can be graphically portrayed (Figure 3), depicting the 722 species named until 2012 for which the primary types are lodged in the Western Australian Museum. This includes 405 spiders, 262 mites and ticks, 36 pseudoscorpions, 15 harvestmen, 14 schizomids, 9 scorpions and 1 palpigrade. Of course, many more species have been described for which the primary types are lodged in other institutions, either nationally or internationally.

While the taxonomic results of the scientific research on arachnids has usually taken the form of papers published in scientific journals, there are growing efforts to deliver online content in the form of web-based

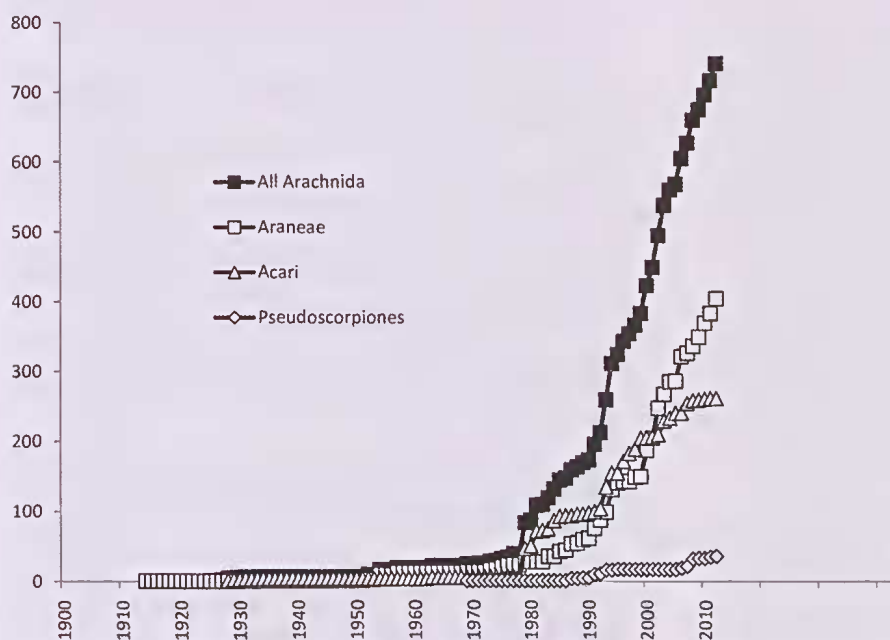


Figure 3 Graph showing primary types (holotypes, lectotypes and neotypes) of Arachnida in the Western Australian Museum collection 1914–2012, showing rapid growth in the documentation and description of new species since the 1980s.

identification guides (e.g. WAMinals – see <http://museum.wa.gov.au/catalogues/waminals/about-waminals>). Spatial data concerning individual arachnid species are also aggregated by different portals including the Atlas of Living Australia (see <http://www.ala.org.au/>), Online Zoological Collections of Australian Museums (see <http://www.ozcam.org.au/>) and NatureMap (see <http://naturemap.dec.wa.gov.au/default.aspx>). These portals provide comprehensive and up-to-date data on the Australian biota to assist managers, ecologists and taxonomists pursue their goals.

A relatively new form of biodiversity documentation has been the recent advent of molecular-sequencing techniques. This method assists in species-level identifications and can provide data on the evolutionary history and relationships within clades. Some notable recent publications with DNA sequence data of Western Australian arachnids include the characterisation of new species of spiders (Harms & Framenau 2013; Harvey *et al.* 2012a; Rix & Harvey 2012; Rix *et al.* 2010) and schizomids (Harvey *et al.* 2008). These modern techniques, when combined with traditional taxonomic descriptions, are slowly combining to form a reasonably comprehensive view of the Western Australian arachnid fauna, providing assistance to managers, biodiversity professionals and ecologists of the significance of the iconic organisms in the Western Australian landscape.

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